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Pattern and correlates of cooking energy poverty among rural households in Lesotho

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Abstract

Despite the availability of cleaner cooking fuel technologies, cooking energy poverty re-mains a prevailing issue in developing contexts, including Lesotho, disproportionately af-fecting the populations. This study examines the differences in the prevalence of cooking energy poverty and it's correlates with a focus on gender disparities in household headship, in Lesotho. Using the 2023-2024 Lesotho Demographic and Health Survey, descriptive sta-tistics, chi-square test, and the logit regression estimation technique, key correlates such as age, marital status, education, household size, wealth, district, and electricity access were evaluated. Firstly, it was established that energy poverty was high among both female and male-headed household accounting for 72.21% of female-headed household compared to 71.10% for male-headed households. Secondly, the result highlights that the distribution of energy poverty differed significantly between female- and male-headed households based on their marital status, educational attainment, district, and access to electricity. The uti-lized econometric modelling (logit regression) showed that there existed gender-based vari-ations in that while older household heads face higher risks across genders, widowed and divorced female heads exhibit heightened vulnerability due to economic insecurity. Educa-tion reduced energy poverty risk for male-headed households but showed limited impact for females, reflecting systemic barriers like wage gaps and labour market discrimination. Larger households and lower wealth status increase cooking energy poverty likelihood irre-spective of gender, but female-headed households often face compounded challenges. These findings underscored the need for gender-sensitive energy policies, targeted subsidies, and empowerment initiatives to alleviate energy poverty and promote equitable transitions to modern cooking technologies.

Keywords: Clean Fuel; Cooking; Energy Poverty; Gender Difference; Household; Lesotho

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1. Introduction

Adequate, reliable, affordable, and clean energy technologies at global, national and household levels are vital for the achievement of many of the Sustainable Development Goals [SDGs] (Ferhi et al., 2024; Jie et al., 2023; United Nations, 2015; Mulugetta et al., 2019). This requires increasing the proportion of population with access to electricity and the proportion of population with primary reliance on clean fuels and technology (UN, 2024). At the household level, energy usage comprises of cooking, heating, and lighting, but the pattern of usage is still a challenge as there is the continual use of poor fuels, reflecting issues of energy poverty. Cooking energy poverty, a subset of broader energy poverty, occurs when households lack access to clean, efficient, and affordable energy sources for cooking purposes, and consequently using inefficient and dirty fuels (IEA, 2023). Despite global advancements in clean energy technologies, over 2.4 billion people still rely on traditional biomass, such as firewood, charcoal, and animal dung, as their primary cooking fuel, globally (IEA, 2023). Also access to modern cooking energy remains uneven, particularly in sub-Saharan Africa and developing Asia (IEA, 2023). According to the IEA (2023), about 988 million persons are estimated to be to be relying heavily on traditional biomass fuels, for cooking purposes in Sub-Saharan Africa continue to despite innovations such as liquefied petroleum gas (LPG), biogas, ethanol stoves, and solar-powered cooking systems that have demonstrated significant potential to improve energy access and the environment. This highlights profound disparities in energy access and infrastructure development, where modern energy solutions remain out of reach for millions of households.

The persistence of this situation has significant implications for several Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy), SDG 3 (Good Health and Well-being), SDG 5 (Gender Equality), and SDG 13 (Climate Action). The reliance on traditional biomass fuels highlights the persistent gap in achieving universal access to affordable, reliable, and modern energy services. The continued dependence on firewood, charcoal, and animal dung for cooking underscores the lack of sustainable infrastructure to provide clean and modern energy alternatives. The widespread use of biomass fuels contributes to indoor air pollution, which the World Health Organization (WHO) attributes to millions of premature deaths annually (WHO, 2022). Women and children, who are disproportionately exposed to harmful smoke due to their proximity to cooking activities, smoke inhalation and indoor air pollution face elevated risks of respiratory illnesses, cardiovascular diseases, and eye infections (WHO, 2022). Also as rightly noted by WHO (2016) and Kyayesimira and Florence (2021), energy poverty reinforces gender inequality, as women and girls bear the burden of fuel collection and cooking, tasks that exposes them to safety hazard and consume significant time and physical effort. This situation impacts educational performance of children, and reduces women or female opportunities for education, employment, and participation in economic and social activities, thereby perpetuating cycles of poverty and disempowerment (WHO, 2016; Imran and Ozcatalbas, 2020; Choudhuri & Desai, 2021). Likewise, the unsustainable harvesting of biomass fuels contributes to deforestation, soil erosion, and biodiversity loss, worsening environmental degradation and undermining climate resilience (Abanikannda and Dantani, 2021; Petrokofsky et al., 2021; Benti et al., 2021). Additionally, biomass burning releases greenhouse gases, contributing to global warming and climate change (Jiang et al., 2024; Lazaro and Baba, 2023).

Household cooking energy poverty is still an existing issue in Lesotho, the country is characterized by significant disparities in access to clean and efficient cooking fuels, especially between rural and urban households. According to the 2023-2024 Lesotho Demographic and Health Survey, while 56% of households

in the country have access to clean fuels and technologies for cooking, 39.9% still rely on solid fuels such as firewood, charcoal, and animal dung. The problem is particularly pronounced in rural areas, where 62.5% of households depend on solid fuels, compared to only 6.8% of urban households (Ministry of Health, Lesotho and ICF, 2024a). This stark divide underscores the issue of cooking energy poverty, where a significant portion of the population, especially in rural regions, lacks access to modern, clean, and affordable cooking energy. As it has been well documented in literature, the continued reliance on traditional biomass fuels has profound implications for health, gender equality, environmental sustainability, and socio-economic development in Lesotho and consequently the country's progress toward achieving several of the Sustainable Development Goals (SDGs). This study aims to explore the patterns and correlates of cooking energy poverty, with a focus on rural households. Moreover, an important aspect of cooking energy poverty that is not fully explored in the Lesotho context is the potential gendered nature of household cooking energy poverty. The gender of the household head may influence the pattern and correlates of cooking energy use. It is possible that female-headed households may face more significant barriers in accessing clean cooking technologies due to socio-economic challenges, limited access to financial resources, and the disproportionate burden of fuel collection. Conversely, male-headed households may have different patterns of energy use and access, shaped by different economic and social structures.

Understanding these gendered differences is crucial for designing targeted interventions that address the specific needs of both male- and female-headed households in improving access to clean and modern cooking solutions. Addressing the gendered nature of cooking energy poverty and understanding the differential patterns based on the gender of the household head is critical for developing equitable policies and interventions. This study therefore seeks to explore the patterns and correlates of cooking energy poverty in Lesotho, with a particular focus on how these patterns differ by the gender of the household head. Specifically, the study addresses the following key questions: (1) Are there differences in the prevalence of cooking energy poverty across various sociodemographic and economic characteristics for female-headed and male-headed households? (2) What are the rural household-level factors that influence cooking energy poverty in Lesotho? do these factors the vary by gender of household head?

2. Literature review: Theory and empirics

The concept of cooking energy poverty has garnered increasing attention in development and energy economics due to its significant implications for health, gender equity, and environmental sustainability. While broader studies on energy poverty exist, research focusing on the specific issue of cooking energy poverty especially in the context of Lesotho remains limited. This review synthesizes theoretical perspectives, empirical findings, and knowledge gaps related to the correlates of cooking energy poverty. The study of cooking energy poverty is often underpinned by the Energy Ladder Hypothesis by Leach (1992) and Amartya Sen's Capability Approach (Sen, 1993). The hypothesis links household fuel choice with economic status of the household (Barnes and Floor, 1996; Leach, 1992), and suggests that households move from reliance on traditional biomass fuels (e.g., firewood, charcoal) to modern energy sources (e.g., electricity, natural gas, liquefied petroleum gas, and renewable energy sources) as their income levels increase. According to the hypothesis, income poverty is a key determinant of cooking energy poverty, as low-income households are more likely to remain at the lower rungs of the energy ladder.

Also, the Capability Approach, which Amartya Sen introduced, emphasizes the importance of human capabilities and well-being. From this perspective, access to clean cooking energy enhances household capabilities, improving health, gender equality, and environmental well-being. Under the Capability Approach, energy poverty is viewed not merely as a lack of energy resources but as a deprivation of capabilities. It goes beyond the ability to pay for energy bills and focuses on how the absence of energy affects people's quality of life and well-being. This perspective shifts attention to what energy enables people to do or achieve in terms of health and well-being, education, economic participation, and social participation. Access to clean energy for cooking reduces indoor air pollution, thereby improving health outcomes. Also, rather than spending long hours seeking unclean fuel like wood, children can spend time studying in the evening if the household has access to clean cooking fuel thereby enhancing academic performance and educational opportunities (Biswas and Das, 2022; Frempong et al., 2021). Clean cooking fuel access by women enables engagement in economic activities and self-development which is crucial for livelihood (Imran and Ozcatalbas, 2020; Choudhuri and Desai, 2021). Similarly, households with access to energy can use devices like phones, TVs, and radios, which promote social inclusion and participation in society. This approach focuses on how energy poverty limits life choices and prevents people from living the kind of life they have reason to value. Both frameworks inform this study's exploration of the socio-economic determinants of cooking energy poverty in Lesotho.

Empirically, evidence from extensive literature indicates a wide range of correlates of cooking energy choices and poverty that include household sociodemographic characteristics, household economic factors, geographic disparities, energy price, and policy-related determinants. *Household Socio-demographic Features:* Household head's gender, age, marital status, and educational attainment and household size are critical socio-demographic determinants of cooking energy poverty. Various studies provide evidence supporting these relationships and highlight the significant effects of these factors on cooking energy poverty. Across the studies conducted on Ghana, Nigeria, and Ethiopia by Dongzagla and Adams (2022), Aminu et al. (2024), and Adugna (2024), respectively, a consistent finding emerges regarding the increasing likelihood and vulnerability of female-headed households to using unclean cooking fuels and experiencing cooking energy poverty. The consensus is that female-headed households face financial, employment, and social constraints, limiting their ability to transition to cleaner energy. Contrary evidence, however, is provided by Burguillo et al. (2022) which demonstrates that in Argentina, there is a reduced probability that a household in which the breadwinner is a woman uses non-modern energy source for cooking. Also, numerous studies (Adugna, 2024; Kitole et al., 2023; Megbowon et al., 2018; Waweru and Mose, 2022; Mothala et al., 2022; Immurana et al., 2023) have demonstrated the impact of the household's age on cooking energy choice, finding that an increase in the age of head increases household reliance on traditional fuel sources due to lower willingness to adopt modern technologies, greater attachment to cultural practices, and limited access to information or financial resources to transition to cleaner energy alternatives. This narrative, however is contradicted by a study on Argentina, which shows that if the household breadwinner is older than 50 years of age, the probability that the household uses non-modern facilities for cooking decreases by 20.30% (Burguillo et al., 2022). Similarly, contrary evidence is presented by Pangaribowo et al. (2023) who demonstrated that the age of household head has a significant positive effect on the use of gas for cooking in Indonesia.

In terms of household size factor, studies by Mainimo et al. (2022) on central Uganda, Oyeniran and Isola (2023) on Nigeria showed that larger households tend to use traditional fuels due to higher fuel consumption need and consequent higher cost implications. Similarly, findings from a study using Ghana as study area show that the likelihood of household cooking energy poverty decreases as increase in household size is

demonstrated to have a significant negative relationship with transitional and modern cooking energies (Kyeremeh et al., 2024). This convergence indicates that household size is a critical determinant of cooking energy choices across different geographic contexts. The place of education attainment of household head and household members in influencing household cooking energy choice and cooking energy poverty cannot be ignored. In the study by Kitole et al. (2023), formal education increases the likelihood of households choosing electricity and industrial gas for cooking. In related finding, education is established to be exhibit a negative association with traditional cooking-energy sources but a positive association with transition and modern energy sources (Aminu et al., 2024). The argument in favour of education level is that as a human capital the level of education relates with level of awareness on consequences or health risk of the use of traditional fuels and the extent to which an individual or household head is able to earn labour wages that can be used for the purchase of modern and cleaner fuels for cooking purposes (Rahut et al. 2020).

2.1. Household economic characteristics

Among the widely studied economic determinants of cooking energy poverty are household income, and wealth status, Income has been demonstrated in various studies (Mothala et al., 2022; Oyeniran and Isola, 2023; Kitole et al., 2023; Kyeremeh et al., 2024; Waweru and Mose, 2022) to significantly influence household energy choices, such that higher-income households are more likely to afford clean and efficient energy sources, such as LPG and electricity. The effect of income in this case is in line with the Energy Ladder hypothesis that conceptualizes a sequential transition from firewood to LPG as income increases (Leach, 1992; Gonz´alez-Eguino, 2015; Burguillo et a., 2022) and the theory of maximum utility under the constraints of household income (Mothala et al., 2022). Also, in line with the Energy Ladder hypothesis is the wealth status of household which is measured by asset ownership, and an indication of affluence that facilitates the adoption of cleaner cooking technologies. This is shown in the study of Megbowon et al. (2018) that as wealth status household improved there was a greater likelihood of using LPG for cooking, whereas the likelihood of using wood decreased. In a related finding, households that attained richer and richest wealth status were 7.10 and 74.48 times more likely to use clean cooking (thereby not cooking energy poor) fuel compared to poorest, in Ghana (Dongzagla and Adams, 2022). Other household economic factors that influence household cooking energy choices and energy poverty identified in literature include employment status of the head, type and sector of employment, and number of income generating activities of household, and number of economically active persons. In terms of number of income generating activities, it is argued that diversified income sources and multiple earners enhance financial resilience, enabling cleaner energy (Aminu et al., 2024). Also, a household having a head that is employed in a formal employment arrangement are better positioned to afford modern energy (Adugna, 2024), whereas households headed by self-employed individuals were found to have negative effects on transitional and modern energies compared with traditional energy (Kyeremeh et al., 2024).

2.2. Geographical location

Studies (Megbowon et al., 2018; Karakara and Osabuohien 2021; Mainimo et al., 2022; Kyeremeh et al., 2024; Oyeniran and Isola, 2023; Ozughalu, 2023; Aminu et al., 2024) have shown that geographical location such as urban-rural residence, region, province or district is a significant predictor of cooking energy poverty and has varying level of impact. Urban households are more likely to use modern energy sources due to better

infrastructure and proximity to energy suppliers. The argument regarding geographical factors include level of poverty, urbanization, extent of difficulty in accessing modern energy sources, level of development of fuel markets, closeness to capital city, and level of rural electrification amongst others. In terms of *Policy-Related Determinants,* national policies such as subsidies on liquefied petroleum gas (LPG), investments in rural electrification, energy pricing and taxation policy, clean energy infrastructure development network, and legislative and regulatory frameworks that prioritize renewable and clean cooking energy sources over traditional biomass, play a vital role in promoting access to clean cooking energy. and have also been shown to reduce reliance on traditional biomass. In summary, the literature review underscores the multifaceted nature of prevalence of cooking energy poverty and its determinants. Drawing on theoretical perspectives and empirical evidences from Sub-Saharan Africa, this study builds on existing knowledge to address the specific context of Lesotho.

Besides, two previous studies on Lesotho's socio-economic and energy dynamics are identified, both studies, however, revealed the limitations of relying on outdated survey data. Makonese et al. (2018) utilized data from the 2009 Lesotho Demographic and Health Survey (DHS) to examine household cooking fuel use patterns and determinants. While their findings provided valuable insights, the use of data collected nearly a decade earlier limited the study's applicability to more recent developments, such as changes in household energy consumption patterns, technological adoption, and economic shocks. Similarly, Mothala et al. (2022) relied on data from the 2017 Household Energy Consumption Survey conducted by Lesotho's Bureau of Statistics. Although this dataset offered more recent insights, it still failed to capture the profound socio-economic disruptions brought about by the COVID-19 pandemic, climate-induced shocks, and global inflationary pressures that have since affected household energy access, affordability, and consumption behaviour. The current study aims to overcome the time gap or limitations by using the 2023-2024 Lesotho DHS survey data, which reflects the country's most recent socio-economic conditions. This approach allows for the assessment of the post-pandemic recovery period, the impact of recent policy interventions, and the effects of climate and economic shocks on household livelihoods. Unlike the 2017 data, which predates these critical events, the 2023-2024 data provide a more accurate reflection of contemporary realities. By incorporating this updated evidence, the current study offers more relevant policy recommendations and supports a forward-looking approach to addressing energy poverty, household welfare, and economic resilience in Lesotho.

3. Materials and methods

3.1. Research design, research method, and data source

This study adopts a cross-sectional research design and employs a quantitative research method. The study utilizes data from the most recent Lesotho Demographic and Health Survey (LDHS) DHS-8 conducted between 2023 and 2024. The LDHS is a nationally representative household survey that collects information on demographic, health, and socio-economic indicators (Ministry of Health, Lesotho and ICF, 2024b). The survey employs a stratified, multi-stage sampling design to ensure that data is representative at the national, urban, and rural levels. For this study, LDHS information on energy use, household socio-economic and demographic characteristics were extracted for analysis. Specifically, only rural households were included, resulting in a final sample of 6600 households. There are no observations with missing data on key variables. The survey

provides comprehensive and reliable data for examining the determinants of cooking energy poverty in Lesotho.

3.2. Model specification and analytical technique

The equation (1) below is employed to investigate the correlates of cooking energy poverty,

$$EP_i = \emptyset_0 + \emptyset_1 household\ head\ age + \emptyset_2 household\ head\ marital\ status + \emptyset_3 household\ head\ education\ attainment + \emptyset_4 household\ size + \emptyset_5 district + \emptyset_6 wealth\ status + \emptyset_7 electricity + e_t \ldots\ldots\ldots\ldots\ldots (1)$$

Where: EP_i = household is cooking energy poor, $\emptyset_1$ = intercept, $\emptyset_1$ - $\emptyset_7$ = coefficients of the independent variables, e_t = error term. The coefficients ($\emptyset_1$ - $\emptyset_7$) indicate the likelihood of a household experiencing cooking energy poverty as a function of changes in the corresponding independent variables.

Descriptive statistics and inferential statistics (chi-square test and logit regression) were used in this study. Chi-Square Test was used to determines whether there is an association between two categorical variables. However, it does not quantify the strength or predict the nature of the relationship. Logit regression model was used to estimate equation (1), to quantify the magnitude and direction of effects of the independent variables on the dependent variables. The model is appropriate for the binary nature of the dependent variable (cooking energy poverty status: 1 = yes, 0 = otherwise). The logistic regression model is estimated using the maximum likelihood estimation (MLE) method. This approach is well-suited for binary outcome models, as it ensures consistent and efficient parameter estimates. The logistic regression model is estimated using STATA 15, to obtain parameter estimates, coefficients, and significance levels. The goodness-of-fit of the logistic model is assessed using the Pearson and Hosmer-Lemeshow tests. Other data analytical technique considered in the study include descriptive analysis and Chi-square test.

Table 1. Summary Description of Variables

Variables	Description
Household Cooking Energy Poverty	Household's non-use of clean cooking fuels (such as electricity, solar energy, LPG, pipe natural gas and biogas). 1 = Poor; 0 is otherwise
Age	The age of household's head in years
Marital Status of Household Head	
Never Married	1 = Yes; 0 is otherwise
Married	1 = Yes; 0 is otherwise
Widowed	1 = Yes; 0 is otherwise
Divorced	1 = Yes; 0 is otherwise
Not Living Together	1 = Yes; 0 is otherwise
Educational: Level of education of household head	
<= Preschool	1 = Yes; 0 is otherwise
Primary	1 = Yes; 0 is otherwise

Secondary	1 = Yes; 0 is otherwise
Higher	1 = Yes; 0 is otherwise
Don't Know	1 = Yes; 0 is otherwise
District	
Butha-Buthe	1 = Yes; 0 is otherwise
Leribe	1 = Yes; 0 is otherwise
Berea	1 = Yes; 0 is otherwise
Maseru	1 = Yes; 0 is otherwise
Mafeteng	1 = Yes; 0 is otherwise
Mohale's Hoek	1 = Yes; 0 is otherwise
Quthing	1 = Yes; 0 is otherwise
Qacha's Nek	1 = Yes; 0 is otherwise
Makhotlong	1 = Yes; 0 is otherwise
Thaba-tseka	1 = Yes; 0 is otherwise
Household Wealth Status: Household wealth Index	
Poorest	1 = Yes; 0 is otherwise
Poorer	1 = Yes; 0 is otherwise
Middle	1 = Yes; 0 is otherwise
Richer	1 = Yes; 0 is otherwise
Richest	1 = Yes; 0 is otherwise
Has Electricity	1 = Yes; 0 is otherwise

4. Results and Discussion

4.1. Descriptive analysis

Table 1 presents the distribution of sociodemographic and economic characteristics of the sample, comparing female-headed and male-headed households. The data reveals that cooking energy poverty is slightly higher among female-headed households, with 72.21% classified as poor compared to 71.10% of male-headed households. In terms of marital status, a significant proportion of female-headed households are widowed (69.37%) or never married (98.11%), whereas male-headed households are predominantly married (71.58%). Educational attainment also differs, with most female heads having only primary education (65.73%), while male heads exhibit a higher proportion with secondary education (18.58%) and preschool education (22.64%). Geographically, household distribution across districts is relatively balanced, but Thaba-tseka has a higher representation of male-headed households (13.53%) compared to female-headed households (11.83%). Economic disparities are evident in wealth status, where 39.16% of female-headed households fall into the poorest category, slightly lower than the 40.71% of male-headed households. However, male-headed households have a marginally higher representation in the wealthiest category, with 5.15% compared to 3.98% among female-headed households. Notably, female-headed households report better access to electricity, with 69.56% having electricity compared to only 30.44% of male-headed households. The total sample size includes 2,638 female-headed households and 3,962 male-headed households.

Table 2. Distribution of sociodemographic and economic characteristics of sample

Variables	Female-Headed Household N (%)	Male-Headed Household N (%)
Cooking Energy Poverty		
Poor	1905 (72.21)	2817 (71.10)
Non-poor	733 (27.79)	1145 (28.90)
Marital Status of Household Head		
Never Married	214 (8.11)	360 (9.09)
Married	351 (13.31)	2836 (71.58)
Widowed	1830 (69.37)	405 (10.22)
Divorced	63 (2.39)	41 (1.03)
Not Living Together	180 (6.82)	320 (8.08)
Educational Attainment of Household Head		
<= Preschool	191 (7.24)	897 (22.64)
Primary	1732 (65.73)	2038 (51.44)
Secondary	500 (18.95)	736 (18.58)
Higher	136 (5.16)	194 (4.90)
Don't Know	77 (2.92)	97 (2.45)
District		
Butha-Buthe	235 (8.91)	414 (10.45)
Leribe	242 (9.17)	451 (11.38)
Berea	252 (9.55)	398 (10.05)
Maseru	195 (7.39)	280 (7.07)
Mafeteng	311 (11.79)	398 (10.05)
Mohale's Hoek	312 (11.83)	353 (8.91)
Quthing	289 (10.96)	327 (8.25)
Qacha's Nek	239 (9.06)	314 (7.93)
Makhotlong	251 (9.51)	491 (12.39)
Thaba-tseka	312 (11.83)	536 (13.53)
Household Wealth Status		
Poorest	1033 (39.16)	1613 (40.71)
Poorer	719 (22.26)	1040 (26.25)
Middle	531 (20.13)	739 (18.65)
Richer	250 (9.48)	366 (9.24)
Richest	105 (3.98)	204 (5.15)
Electricity		
No	1786 (66.57)	2756 (69.56)
Yes	852 (31.76)	1206 (30.44)
Total	2638	3962

4.2. Households sociodemographic and economic characteristics and cooking energy poverty

To answer research question two, Table 2 presents the distribution of cooking energy poverty prevalence across various sociodemographic, economic, and geographical factors. It further uses Pearson's chi-square test to determine the assosiationship or if significant difference exist the categorical variables and cooking energy poverty at a 5% significance level. Key findings include the following, the prevalence of cooking energy poverty varies significantly across sociodemographic and economic characteristics for female-headed and male-headed households. Marital status plays a crucial role, with widowed female-headed households experiencing the highest prevalence of cooking energy poverty at 75.33%, compared to 11.25% among their male counterparts. Married male-headed households, in contrast, show the highest prevalence within their group at 71.85%, while only 11.86% of married female-headed households are affected. This stark contrast highlights the vulnerability of widowed female heads in securing adequate cooking energy. Education level further underscores disparities, as a significant proportion of female-headed households experiencing cooking energy poverty have only primary education (73.07%), compared to 55.84% among male-headed households. Meanwhile, male-headed households with lower education (≤ preschool) have a substantially higher prevalence of cooking energy poverty (28.36%) compared to their female counterparts (8.77%). These patterns suggest that educational attainment plays a role in mitigating energy poverty, particularly for male-headed households.

Regional disparities are also evident. While cooking energy poverty is generally widespread, some districts report higher prevalence rates among female-headed households than male-headed ones. For instance, in Thaba-Tseka, 13.86% of female-headed households experience cooking energy poverty compared to 16.54% of male-headed households. However, in districts such as Mohale's Hoek and Quthing, female-headed households exhibit higher prevalence rates, emphasizing the role of location-specific factors in access to cooking energy. Wealth status is a significant determinant, as both female- and male-headed households in the poorest wealth quintile experience the highest prevalence of cooking energy poverty—53.07% and 56.23%, respectively. While disparities exist across wealth categories, the proportion of affected households' declines sharply in richer and richest categories, underscoring the direct link between economic status and energy access. Electricity access presents another key difference. Among female-headed households, 19.84% have electricity, slightly higher than the 16.83% of male-headed households. This suggests that, despite economic disadvantages, female-headed households might prioritize or have slightly better access to electricity, which could mitigate their cooking energy poverty to some extent.

The chi-square results which provide statistical evidence of significant differences in cooking energy poverty across sociodemographic and economic characteristics for female-headed and male-headed households, show that the distribution of energy poverty differs substantially between female- and male-headed households based on their marital status, educational attainment, district, and access to electricity. Whereas wealth status does not exhibit a statistically significant difference.

Table 3. Distribution of the Prevalence of Cooking Energy Poverty

Variables	Cooking Energy Poor	
	Female-Headed Household N(%)	Male-Headed Household N(%)
Marital Status		
Never Married	98(5.14)	225(7.99)

Married	226(11.86)	2024(71.85)
Widowed	1435(75.33)	317(11.25)
Divorced	37(1.94)	21(0.75)
Not Living Together	109(5.72)	230(8.16)
	Pearson χ^2 (4) = 2.2e+03; Pr. = 0.000	
Education Attainment of Head		
<= Preschool	167(8.77)	799(28.36)
Primary	1392(73.07)	1573(55.84)
Secondary	279(14.65)	347(12.32)
Higher	19(1)	25(0.89)
Don't Know	48(2.52)	73(2.59)
	Pearson χ^2 (4) = 271.90; Pr = 0.000	
District		
Butha-Buthe	177(9.29)	290(10.29)
Leribe	158(8.29)	267(9.48)
Berea	163(8.56)	261(9.27)
Maseru	107(5.62)	145(5.15)
Mafeteng	216(11.34)	286(10.15)
Mohale's Hoek	249(13.07)	269(9.55)
Quthing	212(11.13)	226(8.02)
Qacha's Nek	170(8.92)	226(8.02)
Makhotlong	189(9.92)	381(13.53)
Thaba-tseka	264(13.86)	466(16.54)
	Pearson χ^2 (9) = 48.83; Pr. = 0.000	
Wealth Status		
Poorest	1011(53.07)	1584(56.23)
Poorer	618(32.44)	869(30.85)
Middle	246(12.91)	313(11.11)
Richer	29(1.52)	47(1.67)
Richest	1(0.05)	4(0.14)
	Pearson χ^2 (4) = 7.1080 ; Pr = 0.130	
Has Electricity		
Yes	378(19.84)	474(16.83)
No	1527(80.16)	2343(83.17)
	Pearson χ^2 (1) = 6.9912; Pr. = 0.000	

Source: Computed by Author

4.3. Logit regression result

Table 4 presents the logit regression result on the correlates of cooking energy poverty among rural households in Lesotho. The analysis is disaggregated by gender of household head and estimates coefficients along with their standard errors to assess the probability of cooking energy poverty based on key sociodemographic, economic, and geographic factors. In this context, a positive coefficient indicates a higher

likelihood of experiencing cooking energy poverty, whereas a negative suggests a lower likelihood or protective effect against cooking energy poverty. As shown in the Table 4, the models demonstrate strong explanatory power, with pseudo R-squared values of 50.49% for females and 52.97% for males. High chi-square significance confirms the reliability of the findings, providing robust evidence for policymaking. The logistic regression model's goodness-of-fit statistics demonstrate strong model performance. The Pearson chi-square test yields a chi2 statistic of 3398.11with a p-value of 1.0000 indicating that the model fits the data well.

Table 4. Results on the Correlates of Cooking Energy Poverty Among Household in Lesotho

Variables	Female-Headed Household		Male-Headed Household	
	Coef.	Std. Err.	Coef.	Std. Err.
Household Sociodemographic Factors				
Age of Household Head	0.015*	0.005	0.019*	0.004
Marital Status of Household Head				
Never Married	1	.	1	.
Married	0.627**	0.280	0.377**	0.207
Widowed	0.965*	0.260	0.351	0.272
Divorced	0.913**	0.462	-0.462	0.542
Not living together	0.072	0.314	0.088	0.282
Educational Attainment of Head				
Education Attainment	1	.	1	.
Primary	0.170	0.323	0.232	0.168
Secondary	0.586	0.357	0.099	0.198
Higher	-0.109	0.481	-0.704**	0.339
Don't know	-0.068	0.449	0.516	0.380
Household Size	0.126*	0.031	0.178*	0.027
Household Economic Factors				
Household Wealth Status				
Poorest	1	.	1	.
Poorer	-2.472*	0.255	-2.888*	0.219
Middle	-4.897*	0.281	-5.453*	0.251
Richer	-7.225*	0.374	-7.433*	0.317
Richest	-9.761*	1.063	-9.659*	0.592
Geographical Factors				
District				
Butha-Buthe	1	.	1	.
Leribe	0.287	0.290	0.220	0.213
Berea	0.102	0.303	0.200	0.237
Maseru	-0.209	0.318	0.198	0.244
Mafeteng	0.066	0.275	0.264	0.219
Mohale's Hoek	-0.420	0.303	-0.561**	0.247
Quthing	-0.575***	0.308	-0.832**	0.255
Qacha's	-1.043*	0.325	-0.953*	0.266
Mokhotlong	-1.421*	0.323	-1.350*	0.236
Thaba-tseka	-0.639**	0.324	-0.424	0.269

Has electricity	0.659*	0.171	0.672*	0.144
Constant	2.232*	0.557	2.729*	0.365
Number of Obs.	2638		3962	
LR Chi²(24)	1574.05		2523.61	
Prob. > Chi²	0.000		0.000	
Log likelihood	-771.829		-1120.346	
Pseudo R2	0.5049		0.5297	
Goodness of Fit	Pearson chi2(3751) = 3396.15; Prob > chi2 = 1.0000			
Goodness of Fit	Hosmer-Lemeshow chi2(8) = 3.69; Prob > chi2 = 0.8838			

Source: Computed by Author

4.3.1. Age of Household Head

The age of the household head significantly increases the probability of cooking energy poverty for both female-headed households (coef. = 0.015, $p < 0.01$) and male-headed households (coef. = 0.019, $p < 0.01$). This aligns with priori research that emphasizes older household head inclination to use traditional cooking methods due to cultural preferences, habitual reliance on biomass fuels, and limited adaptability to modern technologies (Adugna, 2024; Kitole et al., 2023; Megbowon et al., 2018). Also, as suggested by Waweru and Mose, (2022) and Immurana et al. (2023) older heads might also face income stagnation due to retirement or declining productivity, which constrains their ability to invest in clean energy alternatives. Conversely, younger heads may have higher education levels and greater exposure to modern energy options, that easily position them to use or transition for clean cooking fuel options. There is no explicit gender-based variation in this finding.

4.3.2. Marital Status of Household Head

The marital status variable significantly influences cooking energy poverty, but the effect varies by gender. According to Table 4, households with married head face higher probabilities of cooking energy poverty (coef. = 0.627, $p < 0.05$ for females; coef. = 0.377, $p < 0.05$ for males). Household with widowed head exhibit even greater vulnerability, particularly for females (coef. = 0.965, $p < 0.01$), indicating economic insecurity after losing a spouse. Divorced heads also show higher likelihood for females (coef. = 0.913, $p < 0.05$) but not for males (coef. = -0.462, $p > 0.10$). Not living together category of marital status has an insignificant effect for both genders. The increased likelihood demonstrated in this study aligns with existing literature that found higher cooking energy poverty likelihood of households headed by married, widowed and divorced persons (Dongzagla and Adams, 2022; Aminu et al., 2024), especially those headed by women to economic constraints and vulnerabilities in the form of income losses and asset depletions following marital dissolution. Studies have also highlighted that female head, in particular may lack access to inheritance rights, unstable income stream or credit facilities, thereby exacerbating their reliance on traditional energy sources. Equally married widowed household heads may face greater household burdens and resource demand, as they often have dependents to support. Households may as well face higher resource demands due to larger family sizes, stretching their budgets. The significant gendered variation in this finding reflects the economic insecurity women often face due to limited access to financial resources, inheritance rights, or credit facilities compared to men.

4.3.3. Education of Household Head

Education has a mixed effect on cooking energy poverty, depending on gender and level of attainment. Specifically, higher education significantly reduces cooking energy poverty risk for male-headed households (coef. = -0.704, $p < 0.05$) but not significant for female-headed households (coef. = -0.109, $p > 0.10$). All other level of education shows increasing likelihood of household to cooking energy poverty but lack consistent statistical significance across genders. The effect of education on cooking energy poverty observed in this study aligns with existing literature that underscores the role of education in influencing household energy choices. Ozughalu (2023) highlights that higher educational levels increase the likelihood of using transition and clean energy sources, driven by enhanced awareness of their benefits and improved income-earning potential. Similarly, Kitole et al. (2023) found that formal education fosters a preference for cleaner fuels such as electricity and industrial gas. This pattern is further supported by Burguillo et al. (2022), who demonstrated that households with less educated breadwinners are more likely to rely on traditional energy sources for cooking. Moreover, Dongzagla and Adams (2022) showed that households headed by individuals with at least secondary education are significantly more likely to adopt clean cooking fuels, attributing this to higher income levels and greater knowledge of health and environmental risks. Indeed, higher education equips individuals (household heads) with skills, employment opportunities, and higher incomes, enabling them to invest in modern cooking technologies. However, despite these positive trends, the disparity in impact observed in this study, where higher education reduces cooking energy poverty risk for male- but not female-headed households, may stem from systemic gender barriers, such as wage gaps and limited economic opportunities for women. These finding points to the need of addressing structural inequities that prevent female household heads from fully leveraging the benefits of education for energy transitions.

4.3.4. Household Size

Household size is associated with a higher probability of cooking energy poverty for both genders (coef. = 0.126, $p < 0.01$ for females; coef. = 0.178, $p < 0.01$ for males). This can be explained by the higher energy demands that come with increasing household size, as more people require meals to be prepared, thereby increasing the reliance on traditional and less efficient energy sources. They are more likely to use traditional fuels, which are cheaper and readily available, to meet cooking needs. Male-headed households show slightly higher likelihood, possibly reflecting higher social expectations for supporting extended families. Findings by Mainimo et al. (2022) on central Uganda, Oyeniran and Isola (2023) on Nigeria both support this perspective, noting that larger households tend to have higher energy needs, which often exceed their financial capacity to afford modern cooking technologies.

4.3.5. Household Wealth

Wealth status shows a strong negative relationship with cooking energy poverty, though very negligible. Compared to the poorest category (reference group: poorest), households in the richer and richest groups have drastically lower probabilities of being energy poor (coef. = -9.7, $p < 0.01$ for both genders). Incremental increases in wealth steadily reduce vulnerability, reflecting the role of economic resources in enabling energy transitions. This is not unexpected because wealthier households can afford modern cooking energy sources such as liquefied petroleum gas (LPG) and electricity, which are often unaffordable for poorer households and

electricity connections, while poorer households remain trapped in cycles of traditional fuel reliance due to financial constraints. This finding aligns with Megbowon et al. (2018), Oyeniran and Isola (2023), Kitole et al. (2023), and Dongzagla and Adams (2022) who all established in their studies that wealthier households are more likely to transition from traditional fuels to modern energy sources. The differences observed in the variable is the strength of impact, which is larger for male-headed households at each wealth status level. Female-headed households are often more vulnerable due to lower earnings, financial constraints or limited income diversification.

4.3.6. Districts

District-level disparities highlight the influence of geography on energy poverty. Households in districts such as Mohale's Hoek, Quthing, Qacha's Nek, Mokhotlong, and Thaba-Tseka are less likely to experience cooking energy poverty compared to the reference district. With remote districts like Qacha's Nek (coef. = -1.043, $p < 0.01$ for females; coef. = -0.953, $p < 0.01$ for males) and Mokhotlong (coef. = -1.421, $p < 0.01$ for females; coef. = -1.350, $p < 0.01$ for males) exhibiting more lower probabilities, respectively. Possible explanations for these differences include disparities in access to energy infrastructure and district-level clean energy initiatives. For instance, Mokhotlong district's lower likelihood ratio suggest that the district may have benefitted from targeted energy programs or investments in clean cooking technology.

4.3.7. Has Electricity

The results indicate that households (either male or female headed) with electricity access have a higher probability of being cooking energy poor (coef. = 0.659, $p < 0.01$ for female; coef. = 0.672, $p < 0.01$ for male). The finding is counterintuitive; it also contradicts some existing research that highlights the complexities of electricity usage in household energy transitions. For example, Aminu et al. (2024), Lokonon (2020), and Adugna (2024) in their studies demonstrated the positive impact of access to electricity on the use of clean fuel for household cooking. A key plausible reason for the finding in this study is the electricity tariffs vis-à-vis household income. The approved electricity tariff for the year 2024-2025 for residences in Lesotho is Maloti 1.905 per kwh, can be said to be on the higher side for many households, especially those in rural areas where incomes are low and only a small fraction are grid-connected. Because cooking is an energy-intensive activity, using electricity (which at this price would considerably raise household energy costs) is not economically attractive. As a result, households would typically rely on traditional fuels like biomass (fuelwood, crop residues, animal dung) for cooking. This reliance persists for many Basothos despite the potential benefits of clean cooking. This plausible reason is consistent with Brown et al. (2020) and Gupta and Pelli (2021), who argue that electrification can inadvertently increase the probability of adopting (free) biomass fuels, as electricity is often prioritized for lighting and small appliances rather than cooking. The finding is further in line with Van der Kroon et al. (2013) who challenged the energy ladder model, explaining that access to electricity does not guarantee a transition away from biomass fuels due to financial and cultural constraints. In terms of cultural constraints or cultural practices could, in some households, cooking practices are deeply ingrained, and there is a preference for traditional cooking methods, such as using firewood or charcoal, even when electricity is available. These practices are often linked to the social context and cooking methods that families have used for generations. Thus, this cultural resistance to change may inhibit the adoption of electricity as a primary cooking fuel, despite its availability.

Evidence from the logistic regression analysis, show that while some correlates (e.g., household size, wealth, electricity access) affect both genders similarly, others, such as marital status and education, reveal significant gender-based disparities. Female-headed households are generally more vulnerable due to systemic socioeconomic disadvantages.

5. Conclusion and limitation

This study was conducted identify possible correlates of rural household cooking energy poverty in Lesotho using the most recent nationally representative Lesotho Demographic Health Survey that covers 6600 rural households. The test results for association-ship between cooking energy poverty and possible sociodemographic and economic factors collectively highlight a strong relationship between household cooking energy poverty status and various sociodemographic, economic, and geographical factors. Furthermore, the result of the logit regression reveals significant factors influencing cooking energy poverty across various household characteristics, including age, marital status, education, household size, wealth, district disparities, and electricity access. Older household heads exhibit higher cooking energy poverty rates due to cultural preferences or income stagnation. Marital status also plays a critical role, with married, widowed, and divorced female-headed households facing heightened vulnerability due to economic constraints. Education demonstrates a gendered disparity, significantly reducing energy poverty for male-headed households with higher education but not for females, likely due to systemic economic inequities. Larger households are more prone to cooking energy poverty, driven by increased energy demands and financial strain. Wealthier households are less affected due to their ability to afford modern cooking energy solutions, though female-headed households remain more vulnerable due to lower earnings. Geographic disparities emphasize the role of district-level infrastructure and initiatives, with some districts performing better in reducing energy poverty. Interestingly, households with electricity access are paradoxically more likely to experience cooking energy poverty, possibly due to prioritizing electricity for non-cooking purposes and cultural or financial constraints.

To address rural household cooking energy poverty, a multipronged approach is necessary. Policies should focus on subsidizing clean cooking energy technologies and fuels, particularly targeting older, female, and economically disadvantaged households. Tailored education and awareness programs promoting the benefits of clean cooking energy should be prioritized, especially in districts lagging in energy transition. Additionally, expanding access to reliable and affordable electricity while addressing cultural and financial barriers to its use for cooking is crucial. Structural inequities, such as wage gaps and limited credit access for women should be tackled to ensure equitable benefits from educational and economic advancements. Lastly, district-level clean energy initiatives should be scaled and customized based on local needs, with targeted investments in infrastructure and programs to support sustainable cooking energy transitions.

This study provides valuable insights into the determinants of household cooking energy poverty; however, few limitations are identified and acknowledged. First, the analysis relies on cross-sectional data, which limits the ability to establish causal relationships between electricity access and cooking energy poverty. While the findings suggest associations, they do not confirm causality, as household energy choices may be influenced by unobserved factors such as income shocks, seasonal variations, or policy changes. Future research using panel data or experimental approaches could provide a clearer understanding of these relationships. Second, the

study does not capture intra-household energy use dynamics in detail. Factors such as gender roles in cooking decisions, household preferences for specific fuels, and perceptions of energy affordability could have provided deeper insights into the persistence of cooking energy poverty despite electricity access. Third, data constraints limit the study's ability to measure the reliability and affordability of electricity, both of which play crucial roles in determining whether households use electricity for cooking. Incorporating qualitative data or household energy expenditure surveys could help refine the understanding of these barriers. By identifying these limitations, the study highlights areas for future research to better understand and address cooking energy poverty.

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